The art of medicine
The singular science of John Snow

John Snow was a scientist of rare dedication, who published more than 100 contributions to the medical literature in a career entirely supported by clinical earnings and terminated by a lethal stroke when he was just 45 years old. The range of clinical and scientific topics covered by his research was wide, although he is most remembered for developing the scientific basis of anaesthesia practice and working out the epidemiology and preventability of cholera. Snow's science was singular in two senses: it was singularly creative and productive; and it reflected a singular, unified scientific approach to the problems he addressed.

As a medical student in London, Snow noticed acute gastrointestinal symptoms among students who dissected cadavers preserved with a newly introduced compound, arsenite of potash. He responded to this problem, as he would often later do, with an experiment. He showed that arsenic was released into air when the preservative was placed in prolonged contact with decomposing tissue. This work on an inhaled toxin was of a piece with a series of studies that addressed respiratory processes and gas exchange in disease states, which prefigured his subsequent work on anaesthetics.

From these beginnings he was well positioned to recognise the problems presented by the newly described practice of surgical anaesthesia. Within a year of witnessing the first demonstration in England of ether for dental extraction, he had published *On the Inhalation of the Vapour of Ether in Surgical Operations* (1847), which explained the key components of good anaesthesia practice. Unlike the situation in the USA, where William Morton, Horace Wells, and Charles Jackson were enmeshed in lawsuits over the priority of ether discovery and profit, Snow's work focused on exactly what to do and how to do it. He was the first to understand that anaesthesia required a precise mixing of agent and air to prevent asphyxiation, and the dependence of that mixture on temperature. His cleverly engineered apparatus (figure) resolved both issues. He developed a five point clinical scale for monitoring the depth of unconsciousness, and kept careful notebooks recording, in diary form, results and side-effects of each procedure. It was Snow who first pointed out that the need to observe the patient carefully meant that someone other than the surgeon should administer anaesthesia and monitor its effects.

The step to becoming a cholera scientist is not so obvious. Snow had treated cholera as a teenage apprentice, assigned to the coal mines near Newcastle in the epidemic of 1831. But he wrote nothing about cholera until 1849, during the world's second cholera pandemic. Although then occupied intensely in experiments with anaesthetics and the clinical practice of anaesthesia, Snow published that year his theory of the faecal-oral transmission of the cholera agent, and the extension of that transmission when water supplies became contaminated with cholera evacuations.

The connection between the two fields was a negative one. Snow's understanding of how substances in gaseous form affected human physiology made it impossible for him to accept the reigning theory of how epidemic diseases arose and spread through miasmatic gases emanating from decaying animal or vegetable material, assisted by atmospheric changes that led to epidemics. This scepticism is muted in his cholera works, where his emphasis is nearly entirely on argument and evidence for his own theory, but found sharp expression in 1855, when he was called on to give parliamentary evidence in relation to the health risks of the "nuisance trades", the bone boiling and hide tanning businesses in London. His argument, scathingly dismissed by *The Lancet*, and met with incredulity by several Members of Parliament, was that these trades, foul though they were, simply did not cause epidemic disease. The effects of gaseous emanations, as he knew well from his anaesthesia work, dropped off by the square of distance from the source. That gases carrying the cholera agent could affect people miles away was to Snow nonsensical.

Working from the clinical features of cholera, Snow reasoned that the disease was restricted to the gastrointestinal system, and that massive fluid loss was the cause of shock and death. He concluded that some agent

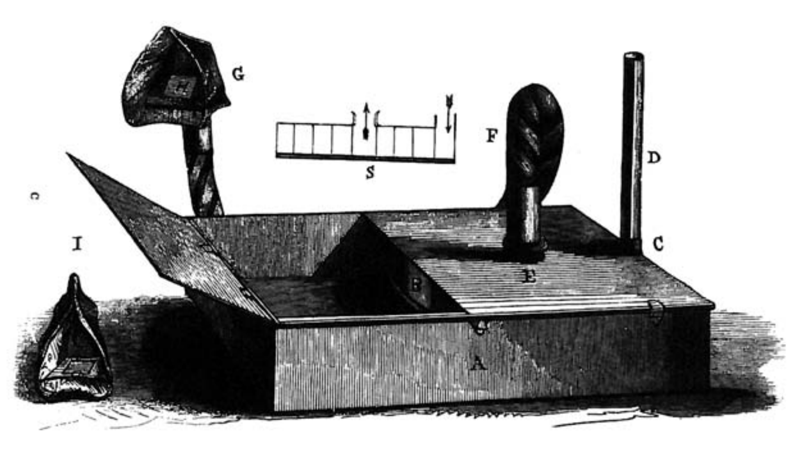

***Figure:* John Snow's anaesthesia inhaler in *On the Inhalation of the Vapour of Ether in Surgical Operations* (1847)**
Snow's description of the ether inhaler: "A. Box of japanned tin or plated copper, of the size and form of a thick octavo volume, serving as a water-bath when the apparatus is in use, and at other times containing the elastic tube and face-pieces. Attached to this by clasps, and moveable at pleasure, is B. The spiral ether chamber, of thin tinned brass, or copper plated with silver. C. Opening in ditto for putting in and pouring out ether, and for screwing on, D. Brass tube, by which the air enters which the patient inhales. E. Another opening in ether chamber for screwing on F. Elastic tube about three feet in length. G. Face-piece. H. Inspiratory valve of ditto. I. The same face-piece compressed, to fit it to a smaller face. S. Section of spiral ether chamber, B."

of disease was in the cholera evacuations, and had to be ingested, not inhaled, to cause disease. In an astonishing flash of insight, he saw that the “special cholera poison” had to be alive and capable of creating progeny, arguing that the 24–48 hours during which the disease was incubating was when the agent of cholera was reproducing, and speculated that the agent “must necessarily have some sort of structure, most likely that of a cell”. All this some 30 years before Robert Koch’s formulation of germ theory.

Snow was not only the first scientist to formulate the faecal-oral mode of transmission, he was the first to propose a theory of disease origin that completely explained the epidemiological features of any disease. His theory explained the propagation of cholera among the poor (no running water, poor light); at wakes (food in proximity to the deceased); and in mines (no separate eating and toilet facilities). His theory correctly predicted high death rates from cholera in London, Glasgow, and Dumfries (sewage-contaminated riverine water) and low rates in Birmingham, Bath, and Leicester (water from rural reservoirs). Snow’s theory was fully set out in *On the Mode of Communication of Cholera* (1849). His more famous second edition, published just after the third pandemic of 1853–54, bolstered the evidence for the theory, but made no change in its fundamental features. The two key pieces of evidence were the acute outbreak near Golden Square that killed some 600 people, and the contrast between cholera mortality rates in South London houses supplied with water by the Lambeth Company (source: the Thames upstream and west of London) and those in houses supplied by the Southwark and Vauxhall Company (source: the Thames at Battersea, just downstream from several London sewers). The Golden Square outbreak, Snow argued, stemmed from a contaminated but popular well at 40 Broad Street. His recommendation, on Sept 7, 1854, to remove the well’s pump handle, was undertaken by authorities the next day, and has since become perhaps the leading symbol of public health action. Snow, however, was not fully convinced of the importance of his intervention. He knew that the outbreak was already on the wane because of “the flight of the population” and openly wondered whether the water in the well remained contaminated with the cholera agent. By contrast, his comparison of homes supplied by the two water companies, with its demonstration of cholera mortality rates during the early phases of the epidemic at least 14 times higher in Southwark and Vauxhall than Lambeth houses, was methodologically more elegant, and harder to refute. It was this latter comparison, not the Golden Square outbreak, that Snow described as an experiment “on the grandest scale”.

Snow’s science reflected a remarkably integrative creativity. In both his anaesthesia work and his cholera research, he blended clinical observations, laboratory experiment, and population-level information. While we might see more chemistry in his development of anaesthetic principles, his categorisation of the depth of clinical narcotism depended on astute neurological observation, and Snow’s use of his casebooks constituted clinical epidemiology at its best. His research into cholera epidemiology in London was a model for population research, but was underpinned by a solid appreciation of cholera pathophysiology. Just as Snow the chemist of gases produced the ideal air-ether mixture, Snow the chemist of water could identify the water of the Southwark and Vauxhall Company. Brackish from the proximity of its source in Battersea to the Thames estuary, the water precipitated silver chloride in the presence of silver nitrate.

Snow was also intensely focused, and knew what needed to be explored and what should be set aside. He was not drawn into the complex investigations made by the General Board of Health into the relation of cholera mortality to every facet of atmospheric and weather conditions, nor did he emulate scientists who examined cholera stools for a possible fungal or parasitic cause. The cholera characteristic to which he devoted all his efforts was its “Mode of Communication”, a phrase used in the title of both of his books, but which is not found in the title of any other book about cholera in the Burroughs Wellcome catalogue of medical books to 1860. While others worried about host characteristics that enhanced susceptibility to cholera or chased potential agents of disease, Snow focused on the dynamics of transmission, on movement rather than stasis, on the verbs of actions, rather than the nouns of characteristics and things. He saw anaesthesia too as a process, a chain of movement that begins with preparing the right air/gas mixture, to making sure it can be delivered to the patient, to monitoring the effects of the anaesthetic, to recording and comparing the results of different anaesthetic agents. He might reasonably have titled the monograph he was working on when he died, “The Mode of Communication of Chloroform”.

Snow the scientist was a practical problem solver, but he could also expound “on the chief phenomena of living beings” in an essay linking reproduction, knowledge transmission, and epidemics. He had an engineer’s appreciation for tool making. He was for the most part a solitary worker, conducting experiments and formulating theories, but he enlisted William Farr and his government staff to extend his assessment of water supply by house. Strong on principle, he did not hesitate to stand up in public and to refute spurious arguments, even when it earned him little favour in the medical or social establishment. He was a singular man.

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Further reading

Snow J. Arsenic as a preserver of dead bodies. *Lancet* 1838; **1:** 264

Snow J. On the inhalation of the vapour of ether in surgical operations: containing a description of the various stages of etherization, and a statement of the result of nearly eighty operations in which ether has been employed. London: Churchill, 1847

Snow J. On the mode of communication of cholera. London: Churchill, 1849

Snow J. On continuous molecular changes, more particularly in their relation to epidemic diseases. London: Churchill, 1853

The Lancet. Editorial. *Lancet* 1855; **1:** 634–35

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